Decision Support System for Determining Employee Income Tax Using the Fuzzy Sugeno Method at BMKG North Sumatra Region

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Abstract
Accurate, consistent, and efficient calculation of employee income tax is essential due to the involvement of multiple components, including basic salary, allowances, deductions, and employee status. Manual calculation increases the risk of errors and requires significant time. This study aims to design a decision support system for determining employee income tax at the BMKG Regional Office of North Sumatra using the Fuzzy Sugeno method. The Fuzzy Sugeno method is selected for its ability to process both numerical and linguistic data through fuzzy rules, enabling more flexible and measurable decision-making. A quantitative approach is employed, encompassing problem identification, data collection, design of input and output variables, formation of fuzzy sets, formulation of inference rules, and system testing. The input variables include base salary, allowances, deductions, and dependent status, while the output is the calculated employee income tax. The anticipated result is a decision support system that enables the agency to determine employee income tax more rapidly, accurately, and consistently. Therefore, the Fuzzy Sugeno method is positioned as an effective solution to support decision-making processes at the BMKG Regional Office of North Sumatra.

Keywords: *Decision Support System, Fuzzy Sugeno, Income Tax, Employees, BMKG*

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2nd International Conference on Islamic Community Studies (ICICS)
Theme: History of Malay Civilisation and Islamic Human Capacity and Halal Hub in the Globalization Era
https://proceeding.pancabudi.ac.id/index.php/ICIE/index

Introduction

Taxes constitute a primary source of state revenue, supporting both governmental administration and national development. Within the framework of personal income taxation, Article 21 Income Tax (PPh 21) serves as a key instrument in personnel administration, as it is levied on income earned by employees through their work, services, or activities. According to the Directorate General of Taxes, taxable income for permanent employees is calculated by subtracting job expenses, pension contributions, and Non-Taxable Income from gross income. This regulation demonstrates that determining PPh 21 involves a complex administrative process that requires careful consideration of various income components and allowable deductions.

The complexity of calculating PPh 21 has increased following the government's implementation of a simplified deduction mechanism using effective rates, as outlined in the official guidance of PMK 168 of 2023. During tax periods other than the final tax period, PPh 21 is now calculated using the effective tax rate table. However, for the annual PPh 21 calculation, the rates from Article 17 paragraph (1) letter a of the Income Tax Law still apply. The result of this study indicate that PT Setyanata Bersaudara had calculated, payment, and reported corporate income tax in accordance with Act. Taxation Number 36 Year 2008 [1].

According to the government's official explanation, this policy aims to establish a tax administration system that is more effective, efficient, and accountable. It is designed to make it easier for employees to verify the accuracy of tax deductions and to help employers minimise the risk of miscalculation. This development highlights that the accuracy of employee tax calculations is now a direct administrative requirement, rather than merely an internal technical concern of an organisation. The data used in this study came from the secondary data that in the form of Income Statement and Annual Tax Return for the year 2013, 2014 and 2015 [2].

The need for accuracy is highly relevant to government agencies that have strategic functions and diverse work structures, including BMKG. Officially, BMKG is tasked with carrying out government duties in the fields of meteorology, climatology, air quality, and geophysics, as well as providing data and information services, issuing early warnings, data management, administrative guidance, and supervising task implementation within the agency. On the other hand, BMKG's mission also emphasises the importance of accurate, timely, complete, and accountable services. At the regional level, employee data from BBMKG Region I Medan shows a diversity of positions, such as Head of BBMKG, Head of Administrative Section, engineer, computer technician, coordinator, and meteorological personnel. The diversity of this job structure logically has the potential to be followed by variations in income components and deductions that must be managed consistently in employee tax administration.

One of the relevant approaches to address this need is the Decision Support System (DSS). In the context of problems involving multiple criteria, DSS is needed so that data processing does not stop at administrative recording, but also produces rational and measurable decision recommendations. The use of a fuzzy decision support system becomes important when the variables faced are not always comfortably separable into absolute categories. A study in the International Journal of Computational Intelligence Systems shows that a fuzzy decision support system can serve as a flexible and robust decision-making platform in complex processes because it can consider multiple criteria, objectives, and constraints simultaneously. This relevance aligns with the issue of determining employee taxes, which fundamentally requires the simultaneous processing of several numerical and categorical variables to produce accountable decisions. The result of this research is that the Sugeno fuzzy method is capable of predicting calculations to determine the level of accuracy [3].

The results obtained based on manual testing and system testing are 16 ready for service and 14 not ready for service. The percentage of system accuracy with manual calculations is 100%, the same as the system calculations. The percentage of influence on motorcycle maintenance is 88.27% in favour of creating this application for motorcycle maintenance to prevent motorcycle accidents [4]. To assist the decision-making process, this study develops a Decision Support System (DSS) that uses the MOORA and MOORSA methodologies, as well as other widely known methods such as SAW, AHP, and TOPSIS. The MOORA method, which is known for its precision in handling several criteria, produces the highest score for A1 candidates of 0.651819. Likewise, the MOORSA method, which includes subjective preferences in its assessment, also provides the best A1 candidates with a score of 0.592177 [5].

Based on the research results using a combination of the Fuzzy Sugeno method and the Analytical Hierarchy Process (AHP), structured planning recommendations can be provided using appropriate methods to support decision-making by Tandi's Homemade Bakery SMEs in improving the production of sweet bread with good quality [6]. Fuzzy Sugeno method. This system helps users in selecting products based on several main criteria [7].

Among various fuzzy approaches, the Fuzzy Sugeno method has a strong position for use in this research. In the case study of determining employee variable pay in a technical institution, the Sugeno fuzzy inference system was used to calculate the components of employee payment and was deemed efficient in handling multiple criteria decision-making issues. This finding is important because it shows that the Sugeno method is not only suitable for technical issues or system control but also relevant for decisions directly related to employee compensation or financial consequences. In the research on determining the amount of PPh 21, the Sugeno method can be utilised to transform various input variables, such as salary, allowances, deductions, and dependent status, into outputs in the form of more definitive and easily implementable tax recommendations within the system.

Literature Review

2.1 Decision Support System (DSS)

Decision Support System (DSS) is a computer-based system designed to assist in the decision-making process, especially when facing unstructured or semi-structured problems. DSS is interactive, allowing users to interact with the system to analyse data and use various models to explore possible solutions. This system integrates data from various sources, both internal and external, and utilises quantitative and qualitative analysis models to provide information that supports better decision-making. With DSS, users can evaluate alternatives, conduct scenario simulations, and make more informed, systematic, and objective decisions in facing the complexities of the problems faced by the organization.

According to Turban (2010, p. 251), a Decision Support System (DSS) is a system that consists of several main components that interact with each other, namely the language system, knowledge system, and problem processing system. Turban (2005, p. 19) also explains that a DSS is not a tool that makes decisions directly, but rather a system that assists decision-makers by providing relevant information from processed data. This information is designed to accelerate, improve the precision, and accuracy in decision-making. SPK is very important in solving semi-structured or unstructured problems, by presenting alternatives that can be used as considerations in choosing the best decision.

2.2 Fuzzy Logic

Fuzzy Logic was first developed by Lotfi A. Zadeh in 1965. This theory is widely applied in various fields, including representing human thoughts into a system. "Fuzzy logic is an appropriate way to map an input space into an output space" (Kusuma Dewi, 2004). There are many reasons why the use of fuzzy logic is often employed, including the fact that the concept of fuzzy logic resembles human thinking. Fuzzy systems can represent human knowledge in a mathematical form that more closely resembles human thought processes. Controllers with fuzzy logic have the advantage of being able to model real-world system behaviour, controlling complex, non-linear systems, or systems that are difficult to represent in mathematical form. In addition, information in the form of knowledge and experience plays an important role in recognising. The Fuzzy system is a system built with clear operational methods, definitions, and descriptions based on Fuzzy Logic theory (Hapiz, 2017).

2.3 Fuzzy Sugeno

Fuzzy Sugeno was introduced by Takagi-Sugeno Kang in 1985 [8]. Sugeno Fuzzy inference is almost the same as Mamdani Fuzzy inference, except that the system output is not a fuzzy set, but rather a constant or linear equation [8]. The process stages in Sugeno Fuzzy inference are the same as in Mamdani Fuzzy inference, from the input variable determination stage to the fuzzy logic operation stage. In the next stage, namely implication to defuzzification, there is a difference [9]. If X is a collection of objects denoted by x, then the Fuzzy set $\grave{A}$ in X is a set of ordered pairs $\grave{A}$ = $\{x,\mu\grave{A}$ $|(x)\epsilon X\}$. The notation $\mu\grave{A}(x)$ is called the membership function or degree of membership of x in A, which maps X to the membership space M located in the range [0, 1]. If M contains only the two points 0 and 1, then A is not Fuzzy and $\mu\grave{A}(x)$ is similar to the characteristic function of a non-Fuzzy set [10].

The value or degree of membership (membership function) is the main characteristic of reasoning with fuzzy logic [11]. Some definitions of fuzzy logic include logic used to explain ambiguity, set logic that resolves ambiguity [12]. Fuzzy logic provides a way to convert linguistic statements into numerical values (Synaptic, 2006). Therefore, something can be said to be partly true and partly false at the same time.

2.4 Sugeno Fuzzy Reasoning

Reasoning with the Sugeno method is almost the same as Mamdani reasoning, except that the output (consequent) of the system is not a fuzzy set, but rather a constant or a linear equation. Michio Sugeno proposed the use of singleton as the membership function of the consequent. A singleton is a fuzzy set with a membership function that has a value at a certain point and 0 outside that point. There are 2 Sugeno fuzzy models as follows:

a. Zero-Order Sugeno Fuzzy Model
   In general, the form of the Zero-Order Sugeno Fuzzy model is: IF ($x1$ is $A1$) ∘ ($x2$ is $A2$) ∘ ($x3$ is $A3$) ∘ … ∘ (xN is AN) THEN $z = k$ where Ai is the i-th fuzzy set as the antecedent, and k is a constant as the consequent.
b. First-Order Sugeno Fuzzy Model
   In general, the form of the First-Order Sugeno Fuzzy model is: IF ($x1$ is $A1$) ∘ ($x2$ is $A2$) ∘ ($x3$ is $A3$) ∘ … ∘ (xN is AN) THEN $z = p1 * x1 + \ldots + pN * xN + q$ where Ai is the i-th fuzzy set as the antecedent, pi is the i-th constant, and q is also a constant in the consequent.
c. Defuzzification:
   The input of the defuzzification process is a Fuzzy set generated from the composition process, and the output is a value. For the Fuzzy IFTHEN rule in the equation RU(k) = IF x1 is $A1k$ and… and xn is Ank THEN y is Bk, where $A1k$ and Bk are respectively Fuzzy sets in Ui R (U and V are physical domains), i = 1,2,… ,n and x = (x1,x2,… ,xn) U and y V are respectively input and output (linguistic) variables of the Fuzzy system. The defuzzifier in the above equation is defined as a mapping from the Fuzzy set B into V R (which is the output of the Fuzzy inference) to a crisp point $y * V$. [2]. In the Sugeno method, defuzzification is performed using the Weight Average (WA) calculation:

$$WA = \frac{\alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \cdots + \alpha_n z_n}{\alpha_1 + \alpha_2 + \alpha_3 + \cdots + \alpha_n}$$

   Explanation: WA = Average value, α_n = predicate value of the n-th rule, and z_n = output value index (constant) of the n-th rule

2.5 Income Tax

Income tax is a tax calculated based on the applicable tax regulations, and it is imposed on taxpayers for the income received or earned within the tax year (Waluyo, 2010). Based on Law

Number 36 of 2008 concerning the Fourth Amendment to Law Number 7 of 1983 concerning Income Tax, hereinafter referred to as the Income Tax Law, it explains that Income Tax (PPh) is a tax imposed on individuals and entities for the income received or earned within one tax year for the benefit of the state and society as an obligation that must be fulfilled.

One of the tax objects of Article 4 paragraph (2) of the Income Tax Law is income from construction service businesses. Wulandari (2019) concluded that construction service businesses are divided into three types: planning, execution, and supervision of construction services. Tax regulations regarding construction services are also specifically regulated, in this case, the imposition of taxes on construction services differs from that of general corporate taxpayers (Nurhayati, 2011). In general, construction activities are divided into three parts, namely (Benny, 2017).

Research Methodology

This research uses a quantitative approach with applied research. The quantitative approach is used because this research focuses on processing numerical data derived from employee income components, such as basic salary, allowances, deductions, and dependent status, which are then processed using the Fuzzy Sugeno method to produce a decision in the form of the employee's Income Tax (PPh). Applied research was chosen because the research results are aimed at solving practical problems in the process of determining employee income tax within the BMKG Region of North Sumatera.

In addition, this research also falls under systems engineering research because it produces a decision support system that is designed, built, and tested to assist in the decision-making process. The focus of the research is not only on mathematical calculations but also on the implementation of the model into a system that can be used by relevant parties more quickly, consistently, and efficiently.

Results

The analysis in this research will cover the system algorithm, system workflow, interface design, and explanations of the forms within the decision support system (DSS). The algorithm of the first-order Sugeno method that will be used in determining the NPWP tax cost is as follows.

The employee sample data used is by inputting Basic Salary = Rp9,000,000, Allowance = Rp2,500,000, Deduction = Rp500,000, and Dependent Status = 2 people. Thus, the output process sought is the amount of employee income tax (PPh) according to the applicable regulations and analysed using the Sugeno fuzzy method.

The next step is to determine the fuzzy variables according to the needs and use 4 variables, namely, the Basic Salary Variable, the Allowance Variable, the Deduction Variable, and the Dependent Status Variable, with the fuzzy set inputs that can be used as follows:

a. Basic Salary
   Variable The fuzzy sets used:
   Medium = triangle [5,000,000, 8,000,000, 11,000,000]
   High = triangle [8,000,000, 11,000,000, 14,000,000]
b. Allowance Variable
   The fuzzy sets used:
   Medium = triangle [1,000,000, 2,000,000, 3,000,000]
   High = triangle [2,000,000, 3,000,000, 4,000,000]
c. Deduction Variable
   The fuzzy set used:
   Low = triangle [0, 500,000, 1,000,000]
d. Dependent Status Variable
   The fuzzy set used:
   Medium = triangle [1, 2, 3]

Calculating the degree of membership
Moderate salary membership degree
Because 9.000.000 falls within the range of 8.000.000 sampai 11.000.000, then:

$$\mu_{medium\ salsary}(x) = \frac{11.000.000 - 9.000.000}{11.000.000 - 8.000.000}$$
$$\mu_{medium\ salary}(9.000.000) = \frac{2.000.000}{3.000.000} = 0{,}67$$

Degree of high salary membership
Because 9,000,000 falls within the range of 8,000,000 to 11,000,000, then:

$$\mu_{highest\ salary}(x) = \frac{9.000.000 - 8.000.000}{11.000.000 - 8.000.000}$$
$$\mu_{highest\ salary}(9.000.000) = \frac{1.000.000}{3.000.000} = 0{,}33$$

so:

$$\mu_{medium\ salsary} = 0{,}67$$
$$\mu_{medium\ salsary} = 0{,}33$$

Determining fuzzy rules In this example, 4 active rules are used.
Rule 1
IF average salary AND medium allowance AND low cut AND medium burden
THEN tax = Rp300.000
Rule 2
IF average salary AND tunjangan besar AND low cut AND medium burden
THEN tax = Rp450.000
Rule 3
IF high salary AND medium allowance AND low cut AND medium burden
THEN tax = Rp500.000
Rule 4
IF high salary AND large allowance AND low cut AND medium burden
THEN tax = Rp650.000

Calculating the firing strength value The AND operator used is minimum.
Rule 1 α1=min (0,67; 0,5; 1; 1) =0,5
Rule 2 α2=min (0,67; 0,5; 1; 1) =0,5
Rule 3 α3=min (0,33; 0,5; 1; 1) =0,33
Rule 4 α4=min (0,33; 0,5; 1; 1) =0,33

Next, the final Sugeno output calculation process is carried out using the Sugeno defuzzification formula.
Substitution of values:

$$Z = \frac{150.000 + 225.000 + 165.000 + 214.500}{1{,}66}$$
$$Z = \frac{754.500}{1{,}66}$$
$$Z = 454.518{,}07$$

Rounded to:
Z≈Rp455.000

Based on the manual calculations using the Fuzzy Sugeno method, the final value obtained is Rp455,000. The value was obtained from the fuzzification process of the basic salary, allowances, deductions, and dependent status variables, then processed through four active fuzzy rules. Subsequently, the output values of each rule were combined using the weighted average method during the defuzzification stage. This result shows that the Fuzzy Sugeno method is capable of producing tax amount recommendations in a measurable way based on the combination of input values entered into the system.

Conclusion

Based on the results of the research and manual calculations that have been conducted, it can be concluded that the Fuzzy Sugeno method can be applied in the Decision Support System to determine the amount of Income Tax for employees at BMKG North Sumatra Region. This method is capable of processing several input variables, namely basic salary, allowances, deductions, and dependent status, through the stages of fuzzification, rule inference formation, and defuzzification, resulting in measurable output values. The manual calculation results show that employee data with a basic salary of Rp9,000,000, allowances of Rp2,500,000, deductions of Rp500,000, and 2 dependents yield a recommended Income Tax amount of Rp455,000. The value was obtained from the combination of active fuzzy rules and calculated using the weighted average method in the Sugeno model.

Thus, the application of the Fuzzy Sugeno method has proven to assist in the process of determining the amount of employee Income Tax in a more systematic, consistent, and efficient manner. The system developed can also serve as a decision-making aid for institutions in managing employee tax calculations, especially when the data being processed has several criteria that must be considered simultaneously.

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